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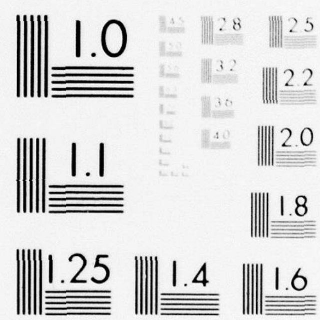

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USING COMMERCIAL TANKERS AND CONTAINERSHIPS FOR NAVY UNDERWAY REPLENISHMENT.

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USING COMMERCIAL TANKERS AND CONTAINERSHIPS FOR NAVY UNDERWAY REPLENISHMENT

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ABSTRACT

SUBSTITUTING MERCHANT SHIPS FOR NAVAL VESSELS, UNDERWAY REPLENISHMENT MISSIONS

The Navy has been looking at alternatives to building additional support ships. Navy design ships are very capable and very expensive. Commercial design ships could save considerable amounts of money. But the operational differences must be taken into account.

"Substituting Merchant Ships for Naval Vessels" (SubMer) is a study conducted by CNA at the Navy's request. It considered the attractiveness of using commercial ships for Navy support missions. Two of the analyses (among others) examined the use of tankers for the underway replenishment of POL, and use of containerships for the underway replenishment of ordnance.

The tanker and containership are not usable "as is" for Navy purposes. They lack rigs for transferring cargo while underway, the Navy's sophisticated navigation and communication systems, a large enough crew to transfer the cargo underway, special cargo pumping or handling equipment, and electrical power for such equipment. The study considered adding this additional equipment to duplicate the capabilities of the Navy ships. But no major structural changes or new ship designs were allowed as these might affect the ship's commercial use, or add considerably to the cost.

The modified commercial ships could be used in two different roles. They could be used for "wartime augmentation" of existing Navy forces when emergency needs arise. Or the modified commercial ships could be used as full "peacetime substitutions" for additional Navy support ships.

The study concluded that there were deficiences in the commercial ships which could not be overcome within the guidelines of the study. The modified tanker had less speed and lower transfer times than the Navy AO. The modified containership had severe safety and cargo transfer problems compared with the Navy AE. However, these commercial ships also represented savings of at least 23 percent in 30 year procurement and operating expenses (dollars are discounted at 10 percent over 30 years). The study did not attempt to weigh the deficiencies against the savings.

The Office of the Secretary of Defense is considering building some future oilers closer to commercial standards. With regard to the containership modification, this study pointed out the need for additional research and development. As a result, an R&D program has been included in the 1981 Program Objectives Memorandum.

USING COMMERCIAL TANKERS AND CONTAINERSHIPS FOR NAVY UNDERWAY REPLENISHMENT

INTRODUCTION

With increasing shipbuilding costs, the Navy has been considering the use of commercial ships in its support missions. As part of this effort the Navy requested the Center for Naval Analyses (CNA) to study the use of tankers and containerships for the underway replenishment of POL and ordnance. This paper summarizes this analysis [1].

The approach used in the analysis is first, to look at the missions that these tankers and containerships could perform. Then these ships can be compared to existing Navy designs to see what additional equipment could enhance the commercial ship capabilities. The costs of these modifications, and the ship's resulting capabilities can then be compared to Navy needs.

Modified commercial ships could be used in two different ways to meet these needs. First, they could serve as direct substitutes to replace building more Navy support ships. Or, the commercial ships could be used for wartime augmentation of existing Navy forces as emergency needs rise. Both of these options were considered as they offer different cost savings, and they view the modified commercial ship's capabilities in two different lights. Deficiencies which may not be acceptable at one funding level, or as the mainstay of the supply system, could prove acceptable at reduced funding levels or for emergency wartime needs.

This analysis is done under certain restrictions. No major structural changes to the commercial ships are proposed; only existing ship designs are used. The ships would be chartered for peacetime substitution and requisitioned for wartime augmentation. In addition, all equipment added to the ships should be existing or state of the art equipment. Wherever possible, preference is given to modular types of equipment that could easily be installed and removed.

These guidelines make the results feasible. The ships and equipment exist, and the engineering required is for implementation of the modifications not for exploratory research and development. The guidelines can thus give the Navy an alternative to building more specialty ships: using existing commercial ships.

TANKERS FOR THE UNDERWAY REPLENISHMENT OF POL

Background

During World War II modified commercial ships performed underway replenishment missions. Since that time, the Navy's UnRep systems have evolved, and commercial ships have changed in design. It is no longer obvious if today's commercial ships can meet the space and structural requirements for the Navy's new equipment.

The commercial tankers were evaluated in 1972 when the Erna Elizabeth was equipped to replenish carriers, escorts, and Navy oilers. The tanker was given an astern fueling rig, and attachment points to handle alongside refueling rigs passed to her by the Navy ships. The test demonstrated inherent differences in ballast capability, freeboard standards, ship speed, pumping rates, and communications between Navy oilers and commercial tankers. Later, the Maritime Administration (MarAd) made preliminary tanker designs that could have eliminated some of these problems. But remaining issues of safety, survivability and performance in war situations were unresolved.

Additional studies have been done. An evaluation of the capabilities of a minimally modified tanker was done by the Naval Ship Missile Systems Engineering Station (NSMSES) [2]. It demonstrated the feasibility of tanker augmentation. Also, a study of the problems and costs of civilian manning of Navy support ships has been completed [3]. This indicated the savings possible by using smaller, but more experienced civilian crews instead of Navy manning of support ships. In addition to these studies, further testing has been done. The Military Sealift Command (MSC) has been operating T-AOS efficiently with smaller, more experienced crews than the original Navy crew. This demonstrated the feasibility of civilian manning.

Mission

There are three basic elements in the Navy's POL supply line. The oil must be moved "point to point" from refineries to forward areas or storage depots. Second, there is the shuttle mission for oilers to move the POL from the storage areas to the deployed fleet. Last, there are the on-station ships, the AOEs and AORs, which actually sail with the fleet and resupply POL to the combatants as needed.

Commercial tankers already perform the point to point mission under MSC charter. They are also suited for the shuttle mission. They can transfer POL to AOEs and AORs using the Navy ships' hoses. They can be modified to carry their own refueling rigs, which would give them the ability to transfer to combatants directly, as well as to supply ships. This additional capability would be needed if the on-station ship were unavailable or lost in action.

The on-station role, however, was ruled out for the tankers by the Navy's requirements that the speed be sufficient to keep up with the maneuvers of the fleet. At best, tankers average about 16 knots, versus the Navy's required 20 knots. It would take considerable changes to the propulsion plant and possibly to the hull of the ship to increase the tanker's speed.

Modifications

Choosing a particular tanker to modify is the next problem. Any of the handy sized tankers between 18,000 and 50,000 DWT would be suitable. Even the Very Large Crude Carriers (the VLCCs) could be used, although draft and length problems could prohibit their entry into many ports [4]. For the CNA study, a Bethlehem Steel tanker was selected that was 37,000 DWT. It had many of the desired features for Navy UnRep: coated cargo tanks, a speed of 16 knots, enough cargo capacity, and sufficient deck space to mount the needed transfer rigs.

In deciding what modifications to make to this tanker, the new AO 177 was the standard of comparison. (See table 1 for the basic characteristics of the tanker and this oiler.) The tanker was then modified to two different levels. Mod 1 was an austere capability -- only enough transfer equipment to do the basic job. Mod 2 was given enough additional equipment as possible to duplicate the Navy oiler, subject to the guidelines mentioned earlier.

TABLE 1

TANKER AND OILER CHARACTERISTICS

		AO 177	Tanker
Length (feet)		592	660
Beam (feet)		88	90
Draft (feet)		32	36.5
Shaft horsepower		24,000	15,000
Speed (knots)		20	16
Generators	Normal use	3-2,500	2-600
(number-kilowatt)	Emergency	1- 750	1-150
Payload (barrels)		120,000	335,000

Modifications that were considered for both Mod 1 and Mod 2 tankers were double valves in the cargo piping to prevent accidental mixing of cargo fuels; a dry cargo transfer station; a helicopter pickup or dropoff zone; a raised Meccano deck for personnel safety; isolated piping for the jet fuel JP-5; additional generator power for the equipment; extra accommodations, lifeboats, etc.; and enough extra piping for cargo transfer, consolidation, etc.

The Mod 1 tanker received two port fuel delivery stations and an astern fueling rig. It was given a communications package similar to what MSC provides on its point to point tankers. The

Mod 2 tanker included extra features to enhance safety and its wartime survivability. These included three port and two starboard fuel transfer rigs; a second forced draft blower per boiler to minimize the risk of a power loss while steaming alongside; an Omega navigation system; an extra gyrocompass; a full Navy communications package similar in capability to the Navy oiler; a charged fire main; a casualty power system composed of jumper boxes and portable rerouting cables; and a second, completely separate set of steering gears.

The Mod 2 tanker still could not match the Navy oiler's capability. The speed remains less (16 knots vs. 20 knots); the pumping capacity is less, and the tankers existing pumps are fewer and larger than the oiler's (which would make any pump breakdown more critical); the tanker could not be given a copper nickel cargo piping or fire main (the cost of the piping alone is high, but the cost of ripping out and replacing the tanker's existing piping would be prohibitive); the tankers do not have segregated ballast which would be useful for maintaining stability during large cargo transfer at sea, and nothing could be done under the guidelines to increase the tanker's compartmentation.

Questions on how these modified tankers could perform cannot be answered directly. But, as part of the Charger Log IV program, point to point tankers have carried out planned consolidations since 1972 with no recorded ship or personnel accidents. MSC tankers have carried out emergency consolidations for 20 years with only one incident recorded. (A tanker was maintaining station and was hit by an approaching oiler.) A last piece of evidence, an MSC tanker was assigned to the Sixth Fleet during the October 1973 Mideast conflict with no accidents.

This history of commercial tankers supporting the Navy involved only astern transfers, or the Navy ships supplying transfer rigs to the tankers' attachment point. Adding the fuel transfer rigs to the tankers, however, should not adversely affect its performance. The modified tanker's intact stability under full load and minimum operating conditions reveal that the tanker has enough inherent stability to handle the modifications [1].

Crew and Accommodations

To keep the cost and crew size of the modified tanker low, a civil service crew could be used. The normal 35 man crew should be increased to 52 and 85 for the Mod 1 and Mod 2, respectively to provide enough men to handle the underway replenishments. The men could be housed in additional structures built onto the ship's existing deck house, or modular containers could be used.

There are some questions as to the acceptability of the container accommodations. Thesse questions revolve around the ship's stability with added topside weight; the safety and strength of the containers and lashings; and the habitability of the containers. Analysis done [1] shows that no major problems exist. The tankers are stable enough to carry the containers. The containers themselves are designed to meet the requirements of deckhouse structures and one such container has withstood such forces in an actual test. The two lashing systems were designed so that either system alone would be adequate. And the containers meet Federal and MSC space regulations as used in reference 1.

The bottom line on the commercial substitution is the cost savings. The procurement and installation costs for the equipment alone would be about $7 million and $19 million for Mod 1 and Mod 2, respectively. The annual operating and charter expenses of the modified tanker would be added to this. In addition, since the ships are in existence today and would be chartered, they could be used for only twenty years. Additional costs are added to repurchase and install a new second set of equipment after twenty years for a total thirty year cost. With these costs and the manning costs added, the Mod 1 tanker had a thirty year peacetime cost of $132 million; Mod 2, $157. A new purchase AO-177 with Navy manning was estimated to cost $234; with civilian manning, $195 million.

These potential cost savings must be weighed against the modified tanker's capability. In the case of Mod 1, the capability is considerably less than the AO 177 class. The Mod 2 still has operational deficiencies: slower speed, longer transfer times due to cargo pumping restrictions, lesser compartmentation standards, no segregated ballast, and a lack of copper-nickel piping.

The wartime augmentation option has some appeal. The necessary equipment would be stored until emergency needs arise. The thirty year peacetime costs of this wartime augmentation option of $4 and $12 million respectively for Mod 1 and Mod 2 are small compared to the thirty year costs of building and operating an oiler. There is, however, one very serious drawback. The commercial tanker modifications would take considerable time to install. The meccano deck and transfer rigs could take 30 to 90 days to install on the tanker in a shipyard with welding and crane facilities. This would be added to the delay for the ship to sail to the closest available shipyard.

One additional point that should be considered is the possibility of expanding the list of National Defense Features for tankers. The current features are added with a point to point role in mind. The tankers are given either astern fueling capability or an attachment point for alongside transfer to Navy oilers or other ships that carry their own transfer hoses. If the shuttle role for commercial tankers is a requirement for the future, then tanker designs could include strong points and deck fittings to ease the installation of the meccano deck, extra space set aside for generators and pumps to be rapidly placed in the ship and "plugged in;" extra accommodation allowances or fittings for the modular containers; extra electrical, piping and water connections to support this equipment. But, this would still only minimize the long delay in the shipyards, not eliminate it.

USING CONTAINERSHIPS FOR THE UNDERWAY REPLENISHMENT OF ORDNANCE

Background

During the 1950s, the U.S. commercial fleet began to turn away from the breakbulk ships toward the containerships. With minimal cargo handling, these new ships offered fast port turnaround times. At first they were designed to be self-sustaining with their own gantry cranes for loading and unloading the cargo containers. As the containerships' popularity grew, the non-self-sustaining containerships evolved, and the ports expanded to supply the needed cranes.

The Navy has traditionally relied on the U.S. commercial fleet for help to meet wartime emergency needs. While containerships can enhance the total sealift capability, they present unique problems for Navy underway replenishment (UnRep) of its own ships.

A joint Navy and MarAd project, the Merchant Ship Naval Augmentation Program (MSNAP), was formed to study these problems. They developed some preliminary concepts and designs to adapt containerships for UnRep [5].

Mission

The containership could perform the point to point resupply mission with little modification. The main consideration is whether the originating and receiving ports are equipped to handle containerships, i.e., whether they have cranes at the pier and if the piers have sufficient strength and room for such offloads. Emergency offloads without such facilities are possible and were demonstrated in the LOTS test (Logistics Over The Shore) where cranes on barges and on the ship's deck offloaded containers to waiting barges.

For the shuttle mission an ordnance ship needs easy access to all its cargo. It should have provisions to move cargo within the storage areas and to the main transfer deck. The transfer deck itself is equipped with the STREAM (Standard Tensioned Replenishment Alongside Method) rigs that pass cargo between ships while automatically adjusting for the ship separations while sailing alongside.

The containership, however, presents many problems for such cargo transfer. First, its cargo is stored inside containers that are stacked in the holds or on deck. In some cases there is no way to even get to the container, let alone open its doors and remove cargo. There are no deck levels in the holds -- the holds are just large open spaces with steel guides to hold the container stacks in place.

Given these constraints, one possible solution would be for heavy lift helicopters to transfer fully loaded containers of cargo that are placed within easy reach. (Connected replenishment by highlines would not be possible with such heavy loads.) But this would require the replenishment containership to have a complete list of needed goods from the consuming ships far enough in advance to selectively fill the containers and load them in port. This is obviously not an optimal solution. It delays the resupply of ordnance, and makes no allowance for last minute needs of combatants.

The OSDOC II (Over the Shore Discharge Of Cargo) tests noted additional difficulties in container transfer. A transferred container's space and equipment needs overwhelms the combatant's cargo handling capability. The helicopters had a hard time placing the containers correctly on deck. Also, helicopters that removed MilVan containers from the containership's holds were not able to reinsert emptied containers creating a retrograde problem. (These were tests conducted in good weather with less than six degrees roll.)

The COTS (Container Offloading and Transfer System) tests used a crane on the ship's deck for unloading containers from an anchored ship. Serious questions were raised about the stability of such cranes for lifting hatch covers and fully loaded containers underway. They concluded that rolls of five degrees or more could cause the cranes to collapse. (This questions the advantage of using self-sustaining containerships for UnRep.)

Given these problems, it seems best to adapt the containership for pallet load transfers. Deck levels must be established; individual container loads must be made accessible; vertical movement from the holds to the transfer deck must be provided. In addition, cargo transfer rigs for connected replenishment must be added to resupply on-station support ships and for emergency resupply of combatants. These modifications could give the containership a shuttle mission capability.

The containership would not be suitable for the on-station role itself. The reasons for this will be brought out in the discussion of modifications which follows. Briefly, it cannot support the STREAM transfer gear without major structural changes to the ship. This lack of STREAM transfer would severely limit its ability to transfer ordnance to combatants on a regular basis.

Modifications

For the purposes of this paper, a typical non-self-sustaining containership will be considered. (There are more non-self-sustaining containerships than self-sustaining, 85 versus 19.) The particular ship addressed here is the C6-S-85b, built by the Ingalls Shipbuilding Division, Litton Systems. It is one of the newer designs being built, and it has a favorable deck layout. ("Favorable" here refers to the deckhouse either fore or aft -- not amidship -- which leaves the largest amount of space for cargo access, handling and transfer.) Table 2 compares the basic characteristics of the C6-S-85b with the Navy AE 26 class.

TABLE 2

AE AND CONTAINERSHIP COMPARISON

	AE 26	C6-S-85b
Length overall (feet)	564	669
Beam (feet)	81	90
Draft (feet)	28	33
Cargo capacity (long tons)	6,500	15,270[a]
Displacement (long tons)	20,000	30,300
Sustained speed (knots)	20	23

[a]After modifications the actual UnRep cargo capacity is about 7200 long tons.

The main deck of the containership is not usable "as is." The holds are covered by hatch covers which sit on coamings two to four feet above the main deck level. The aisles between these hatch covers are four to six feet longitudinally and only about a foot apart athwartships. This is too small for forklift truck traffic.

To avoid this problem, a new UnRep transfer deck can be established. Small bridges between the hatch covers would form a solid surface. The hatch covers themselves cannot support the weight of forklifts loaded with ordnance. (The hatch covers normally support stacks of loaded containers, but the covers' strength, like the containers', is concentrated in the corner supports.) The hatch covers can be reinforced by using airfield matting.

Cargo on containerships is commonly carried on the main deck or in the holds beneath the deck. Much of the main transfer deck on the modified containership, however, is needed for the UnRep activity, or is not convenient for cargo storage. The area above the forward hold is raised too high above the rest of the transfer deck to be accessible for fork lift trucks. The area behind the deck house will be needed for additional accommodations. The remaining area is broken up by the transfer equipment, elevator housing, maneuvering space for the fork lift trucks, and space for prestaging the cargo.

Deck cargo containers are normally stacked up to four high in commercial service. Some of the containers, however, may actually be empty, and are just behind shipped to avoid container distribution problems. The weight limitations of the hatch cover are what really determines the height of the containers carried. For the C6-S-85b the weight limit is 31 to 47 short tons. Loaded with a high density cargo such as ordnance, it is unlikely that a height of more than two containers could be achieved, as each container has a gross weight allowance of 22.4 tons.

There is another consideration for keeping the container height on deck to only one container. There is currently no safe way of unloading ordnance at sea from the height of two containers or more. A Naval research program under the Naval Sea Systems Command is currently investigating one such system [6]. It is a platform raised or lowered by a wire rope winch. Another winch mounted on the platform itself pulls the pallet load out of the container onto the platform. The whole structure is supported by parallel channel guides fastened to the container stack.

Actual design was completed in 1978; a prototype is being fabricated. The system has not been evaluated for performance and safety. It is possible with such a system that a second or third layer of light weight cargo could be carried above the ordnance container.

Thus most of the cargo will be in the holds. Providing access to these holds is the next problem. As the hatch covers themselves weigh 9 to 29 tons apiece, they cannot be lifted safely at sea. The MSNAP program suggested that elevator access holes be cut through the hatch covers, (and the matting cover as well), for installation of existing types of Navy cargo elevators [7]. These holes in the hatch covers could be cut and fitted with watertight covers for times when the containership was in regular container service. The cover plates could then be removed at port for UnRep duty. Figure 1 shows one such hatch cover modification.

The containership also needs a connected replenishment system for cargo transfer. Navy UnRep ships have kingposts standing 40 feet above the main deck with STREAM rigs. The kingposts are built to withstand a horizontal pull of 50,000 pounds at the top. Typically, M-frame or H-frame structures are used, and these are built into the strong points of the ship itself.

Estimates from the Navy and MarAd for such structures on the containership suggest that posts about four to five feet in width and with a total length of 80 feet would be needed. The only points in the containership that would be strong enough to support such posts would be at the edge of the ship. This position would not allow sufficient room for the loading and unloading of cargo. Adding the kingpost anywhere else would involve major structural changes.

A modular alternative to such a kingpost is the portable sliding padeye designed and tested by the MSNAP program. This sliding padeye is a cargo highline attachment point 18 feet high. Their height is enough to lift the cargo over the ship's rail, but not so high as to cause problems securing the post. The padeye has winches to raise and lower the cargo.

A portable I-beam foundation was designed to mount the padeye and attach the needed backstays. The padeye and foundation is portable in the sense that it could be lifted by crane to a new location and does not require welding to the ship's deck. Once positioned, it could be held down with restraining clamps and cables.

This sliding padeye cannot carry its own STREAM equipment. It is not high enough or strong enough. It can be used as an attachment point for STREAM equipment carried by an on-station Navy AOE, AOR, or AE. Thus transfer between the modified containership and the Navy on-station ship could proceed at a fairly reasonable rate, and would be governed mainly by the number of transfer stations available on the containership, and the efficiency of the cargo movement on the containership.

However, for the emergency resupply of combatants, the modified containership would have to carry its own transfer gear. Housefall rigs could possibly be devised to handle this transfer, but the height of the padeye and the rigging problems involved could cause severe weight restrictions on the loads transferred, and on the allowable separation between the sending and receiving ships. Even if the Housefall transfer worked, and this is not proven, it would take at least twice as long, and possibly more.

Thus the modified containership can act as a shuttle ship to the on-station supply ship. It does not have a strong backup capability to resupply combatants. This is one serious drawback for Navy UnRep use. Further study to provide attachment points that are modular, and yet can support STREAM rigs is needed to overcome this problem.

For moving the cargo up from the holds to the transfer deck, elevator systems could be installed, again following the MSNAP concepts [8]. A vertical stack of containers in the hold would form the elevator shaft. Holes cut in the top and the bottom of the containers would allow the elevator platform to pass through the container "floors." With the end doors removed, and additional holes cut in the sides of the shaft containers, there would be access to the elevator from several directions. The elevator would pass through the hatch cover hole on to the

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These elevator systems could be used on containers of varying sizes, By using actual containers, this allows considerable flexibility for the size of the cargo carried (for example, large missiles) and for the different containerships available for UnRep use. For wartime augmentation, the container shaft could possibly be constructed at the port when they were needed.

The main difficulty in the elevator shaft proposal is structural. Keeping such a container stack rigid enough to be within current engineering allowances may prove difficult.

With most of the cargo stored below deck, access to individual items must be provided. However, container doors are blocked by the cell guides, and the other stacks of containers. There is no deck floor to drive fork lift trucks from one location to another.

A solution to this problem is to replace the containers with flat racks, as pictured in figure 3. These are basically designed as containers without sides or tops. There is a strong floor to support the cargo, and reinforced corner posts to allow the flat racks to be stacked. This construction allows access to the cargo from any side. By leaving some of the flat racks empty, and providing bridging between neighboring flat racks, the equivalent of a roadway can be formed. (There are flat racks currently in commercial service. About 1600 such units exist in the commercial inventory, but they are not used in this manner.)

There are problems with the flat racks. First, some sort of cargo tie downs must be devised. The tie downs could use only the flat rack floor and corner posts for securing the cargo, and must allow individual cargo items to be removed. Secondly, the bridging between the flat racks depends on the normal separation distances between the containers in the hold. This distance varies from one class of ship to another. This would mean a package of bridging ramps may be needed for each different class of ship.

Other necessary modifications would be needed. Additional generators to support the accommodations, sliding padeye stations, elevators, forklift truck recharging, Navy communications van, etc. would be added. Some containerships have National Defense Features providing not only such electrical connections, but also, connections for accommodation's water and sewage. They also have space allowances for the rapid installation of additional generators.

Also needed would be lighting in the holds, additional fire-fighting capability, containerized storage and recharging containers for the forklift trucks, electric forklift trucks and other cargo handling devices, cargo securing devices, a helicopter pickup and dropoff zone, and a Navy communications van.

Crew and Accommodations

To handle the UnRep duty, the containership crew would have to be enlarged. The existing crew is 47 men. For cargo operations at sea a crew of about 160 would be needed. Thus additional galleys, lounges, accommodations, etc. must be added. Containerized accommodations could easily be mounted behind the deck house structure on the main deck of the C6-S-85b. This location would shelter the containers somewhat from the effects of the wind and sea. It would also provide the crew with quick access to the main deck house.

SUMMARY

Thus modified, a containership could probably perform shuttle UnRep duty between ports and deployed on-station supply ships. However, there are deficiencies and uncertainties about the modified containership's ability to perform these duties well: cargo transfer to on-station supply ships would be slower than from an AE; transfer to combatants would be very difficult and time consuming; Navy and Coast Guard regulations for explosive ordnance compatibility and safety would have to be addressed; and bridging equipment for the transfer decks and flat racks may not be usable between different classes of ships. These deficiencies make the containership undesirable for peacetime substitution.

On the other hand, having the ability to quickly modify containerships for wartime augmentation has great appeal with the large numbers of containerships in the commercial fleet today. The modifications are all modular and are designed to be loaded in four days by the cranes used in regular commercial service. The cost for additional Navy AEs is close to $300 million (in thirty year discounted dollars), compared to about $25 million for a containership augmentation capability. And, additional research and development may reduce the deficiencies of a modified containership to a more acceptable level.

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